CLIMATE CORRECTION OF BULK METER CONSUMPTION

Tim Harrold, Pierre Mukheibir
Wannon Water, Warrnambool, VIC

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ABSTRACT

Wannon Water has adopted a demand reduction program that aims to achieve real savings in water consumption. Since it is beyond the control of the Authority, climate-related variations have been taken into account when assessing the effectiveness of this program. A linear regression was developed using a single predictor, evaporation, to assess the trends in water consumption under demand side management strategies.

Evaporation was found to explain between 60% and 80% of variability in consumption, depending on the location. Based on hindcasts over the 40 year period for the eastern zone, the fitted model suggests that consumption in January, for example, may vary by ± 10% due to climate variability. When compared with actual consumption, the climate correction factor for the Eastern zone was calculated to be 96.3% for 06/07 and 98.7% for 07/08.

The conclusion was that, in climate-corrected terms, consumption has declined steadily over the past two years, and Wannon Water is on track to reach or exceed its 2015 demand reduction targets.

INTRODUCTION

Wannon Water provides water supply to approximately 79 000 people in Southwest Victoria. In June 2007, Wannon Water adopted a water demand reduction program that aims to achieve real savings in consumption. In order to determine the true effectiveness of interventions which are under the control of the authority, climate-related variability may be taken into account when assessing the effectiveness of this program. This paper reports on the climate correction of Wannon Water's bulk meter consumption.

The climate correction of consumption records is important since the influence of climate over a relatively short period of time (eg two to five years) can lead to distorted conclusions of both the current level of water demand and recent trends.

METHODOLOGY

A number of approaches and tools have been developed to assess the impact of climate on demand, most of which involve complex modelling programmes (Beatty et al. 2006, DEUS 2002). The approach in this study was to employ a simplified model using a single predictor to assess the trends in water consumption under demand side management strategies. The interest was not in the absolute values of the climate corrected demands.

The analysis in this study was undertaken in three steps:

Calibration – where the historical baseline was calibrated for a 5 year period to determine the correlation factor;

Hindcasting – where the available climate data was used to project the water demand for the past 40 year period using the calibrated model. The month of January was used as an illustrative example. The results were used to determine the expected variability of predicted consumption in subsequent years for the month of January.

Climate correction – where the observed consumption was compared with those predicted by the calibrated model to illustrate the impact of climate on the daily and seasonal demand for 2006/07 and 2007/08.

Climate corrections were made based on linear regression between climate variables and monthly consumption data over a calibration period of July 2002 - June 2007. Three variables have generally been found to be significant when determinining the impact of climate on water demand (MWH 2005), viz rainfall, pan evaporation and maximum temperature (Tmax). These were evaluated to find the best predictor of demand for the Wannon Water Eastern supply region.

This is to confirm that the paper submitted and presented by Dr Pierre Mukheibir titled 'CLIMATE CORRECTION OF BULK METER CONSUMPTION' was peer reviewed in two formats.
The first was the extended abstract peer reviewed for acceptance to present, and then the completed paper was peer reviewed prior to presentation and published on the AWA website after presentation at the conference.
If you require any further information please feel free to contact me.
Regards

Despina Hasapis
Senior Events Manager
Australian Water Association
Level 6, 655 Pacific Highway / PO Box 222
St Leonards NSW 1590
Direct**:** 02 9467 8414

In developing the model, the Eastern Zone was first assessed as a whole and then the method was applied to specific supply locations in Southwest victoria.

RESULTS

Eastern Zone

Terang was chosen as a representative location for the climate of the Eastern Zone. Daily climate data for 1970-date for Terang (maximum temperature, daily evaporation and daily rainfall) was obtained from the Queensland Department of Natural Resources and Mines' SILO Datadrill website (DNR 2008). This data was aggregated into monthly values.

The monthly evaporation at Terang is high in 2006/07 compared to the average over the five year period (2002-2008), as shown in Figure 1. The 2007/08 evaporation on the other hand tracks more closely with the average.

Using the monthly data for July 2002 – April 2008, the variables Tmax (maximum daily temperature averaged over a month), Evap (mm/month) and Rain (mm/month) were evaluated to see how well they explained variations in consumption. Evaporation was selected as the best predictor with a correlation of 77% the Eastern zone. Table 1 shows that monthly rainfall only explained about 23% of the variation in monthly consumption for this area and hence was not cosidered reliable as a predictor for this region. Tmax was also not as reliable as Evaporation for most locations, as shown in Table 1.

Examination of the data revealed a different relationship between evaporation and consumption for "winter" months (May-August) compared to "summer" months (September-April). Evaporation explains 68% of the variation in monthly consumption over summer, as shown in Figure 2, whereas the correlation was very low for winter. Based on Figure 2, a model for predicting consumption for a given evaporation during summer months is:

$$PC(x) = 0.0835x + 14 \qquad \textbf{Eq 1}$$

Where,

x = evaporation in mm/month

PC = predicted consumption for that month, expressed in ML/d.

A methodology for climate correction of monthly consumption for "All East Bulk Metered Zones Combined" is:

Summer: Consumption is corrected as follows:

$$CCC = PC(\bar{x}) + AC - PC(x) \qquad \textbf{Eq 2}$$

Where,

CCC = climate corrected monthly consumption

AC = actual monthly consumption

$\bar{x}$ = average evaporation for that month (2002-2008).

Winter: No climate correction, i.e.

$$CCC = AC \qquad \textbf{Eq 3}$$

To test the predicted consumption, a hindcast was carried out on January consumption from 1970-2008. The predicted consumption in Figure 3 was calculated using the SILO data for the Terang January evaporation. The hindcast gives a January consumption of 30.5 ML/d ± 10%. That suggests that the consumption for January may be expected to vary by ± 10% due to the influence of climate.

Figure 4 shows the climate corrected consumption for 2006/07 and 2007/08 (note that no climate correction was made for winter months). As would be expected, climate-corrected consumption was lower than observed consumption in those months where evaporation was relatively high (for example in October 2006).

In general, the Eastern zone 2006/07 climate-corrected consumption is close to average for the first half of the financial year and at or near the minimum observed for the second half of the financial year. Apart from a downwards correction in March 2008, the 2007/08 climate correction does not make much difference since evaporation is close to the average. For this period, the consumption is generally at or below historically low levels.

Applicability for specific locations

At all other locations tested in Southwest Victoria, evaporation was the best single predictor of consumption, explaining between 60% and 80% of variability in consumption, depending on location (see Table 1). Rainfall only explains around 23% of the variability in consumption. In every case, the data suggested that the climate correction should be made for "summer" months (September to April) and that no correction is justified for the "winter" months (May to August) due to the poor correlation (See Table 2).

For summer months, the residuals from equation 3 (i.e. AC–PC(x)) were plotted against both rainfall and Tmax for locations in Southwest Victoria. The correlation factors (R^2) obtained from this analysis are shown in Table 3. The median residual R^2 was found to be 0.04 for rainfall and 0.04 for Tmax. These correlations are too low to justify addition of these predictors into the climate correction model.

Based on hindcasts over the 40 year period where evaporation is available, the fitted models suggest that consumption in January may vary by the following percentages due to climate variability:

- "All East"	+- 10%
- Warrnambool	+- 10%
- Camperdown rural	+- 13%
- Camperdown	+- 14%
- Terang	+- 12%
- Cobden	+- 8%
- Hamilton	+- 20%
- Portland	+- 15%
- Port Fairy	+- 14%.

Effect on major industry consumption

Major industry displays a lower sensitivity to climate variations than other customers of Wannon Water. When the data was adjusted by removing major industry to leave only residential and non-residential demand, the sensitivity to climate increased (See Table 4).

Annual climate corrections for 2006/07 and 2007/08

Climate corrected annual consumption can be obtained by summing the monthly results. The results for a number of towns are shown in Table 4. All these towns were free of water restrictions over this period. Climate correction was not attempted at towns under stage 3 or stage 4 water restrictions, such as Hamilton. Water restrictions suppress demand and remove most of the seasonal influence on demand due to restrictive water use and garden watering.

It was found that 2006/07 had high evaporation, and the climate corrected consumptions were generally lower than the observed consumptions. 2007/08 had slightly above average evaporation, and the climate corrected consumptions were closer to observed consumptions.

Even though some months have large climate corrections (e.g. October 2006 in Figure 5), the climate correction over the entire year tends to be moderated by other months being closer to an average climate. This results in an overall correction factor for 2006/07 of about 96.3%, and for 2007/08 of about 98.7%, as shown in the table. For 2005/06, the overall correction was small, in the order of 100.4%, and hence no corrections were made for this year.

The climate correction smooths the observed reduction in annual demand (see row 2 in Table 4). In climate-corrected terms, the overall demand across these customer zones has been declining steadily for the past two years and Wannon Water is on track to reach or exceed its 2015 demand reduction targets.

CONCLUSION

The best predictor of demand (out of rainfall, temperature and evaporation) is evaporation, which explains between 60% and 80% of variability in consumption, depending on the location. Rainfall only explains around 23% of the variability in consumption. The data suggested that climate correction should be made for "summer" months (September to April) and that no correction is justified for "winter" months (May to August).

The key conclusion is that climate corrected consumption provides a more accurate trend of the demand and a more consistent tool for demand management strategy development.

REFERENCES

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Table 1: Correlation factors (R^2) for three climate variables per distribution system

	Rainfall	Temperature Max	Evaporation
Total Eastern zone	0.23	0.78	0.77
Warrnambool	0.26	0.56	0.66
Camperdown - rural	0.25	0.79	0.81
Camperdown - urban	0.19	0.71	0.72
Terang	0.23	0.62	0.59
Cobden	0.07	0.43	0.65
Portland	0.38	0.66	0.72
Port Fairy	0.18	0.54	0.60
median	**0.23**	**0.64**	**0.69**

Table 2: Correlation factors (R^2) for the Summer and Winter months per distribution system

	Full year	Summer	Winter
Total Eastern zone	0.77	0.68	0.03
Warrnambool	0.66	0.63	0.01
Camperdown - rural	0.81	0.73	0.08
Camperdown - urban	0.72	0.62	0.05
Terang	0.59	0.66	0.00
Cobden	0.65	0.46	0.20
Portland	0.72	0.68	0.00
Port Fairy	0.60	0.60	0.06
median	**0.69**	**0.65**	**0.04**

Table 3: Correlation factors (R^2) for Summer residuals plotted against Rainfall and Tmax

	Rainfall	Tmax
Total Eastern zone	0.05	0.06
Warrnambool	0.00	0.00
Camperdown - rural	0.04	0.05
Camperdown - urban	0.04	0.04
Terang	0.06	0.06
Cobden	0.04	0.01
Portland	0.02	0.03
Port Fairy	0.00	0.02
median	**0.04**	**0.04**

Table 4: Annual Climate Corrections for 2006/07 and 2007/08

	Bulk meter Consumption			Climate Corrected Consumption		Climate correction factor	
	05/06	**06/07**	**07/08**	**06/07**	**07/08**	**06/07**	**07/08**
All Eastern zone	9149	9056	8352	8724	8246	96.3%	98.7%
Percentage change against previous year	0.0%	-1.0%	-7.8%	-4.6%	-5.5%		
Warrnambool	4775	4630	4441	4468	4385	96.5%	98.7%
Warrnambool ex. Majors	3884	3830	3635	3670	3580	95.8%	98.5%
Camperdown rural	802	824	735	784	722	95.2%	98.2%
Camperdown	422	413	388	391	381	94.6%	98.1%
Terang	283	273	265	261	261	95.7%	98.5%
Cobden	789	871	736	850	729	97.6%	99.1%
Cobden ex. Majors	378	407	355	390	350	96.0%	98.6%
Portland	1848	2233	2179	2136	2145	95.6%	98.5%
Portland ex. Majors	1158	1581	1622	1494	1592	94.5%	98.2%
Port Fairy	727	847	826	817	820	96.5%	99.2%
Port Fairy ex. Majors	557	714	668	682	661	95.5%	99.0%

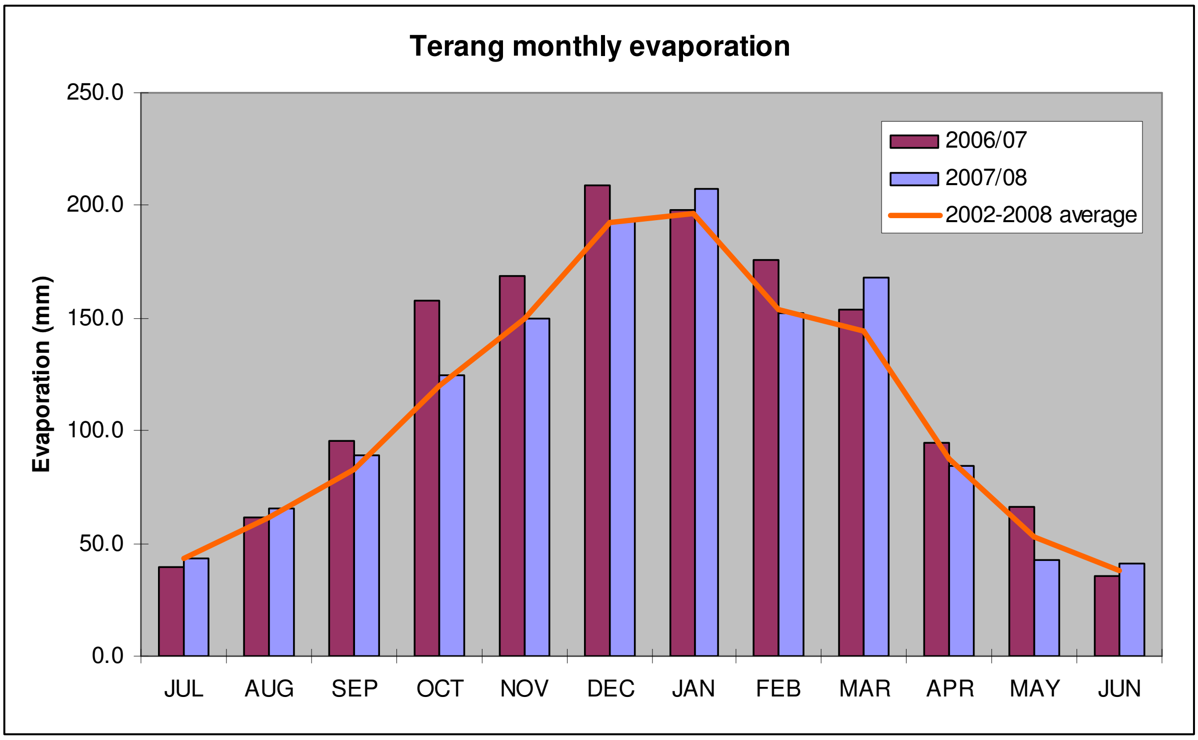

Figure 1: Monthly evaporation at Terang

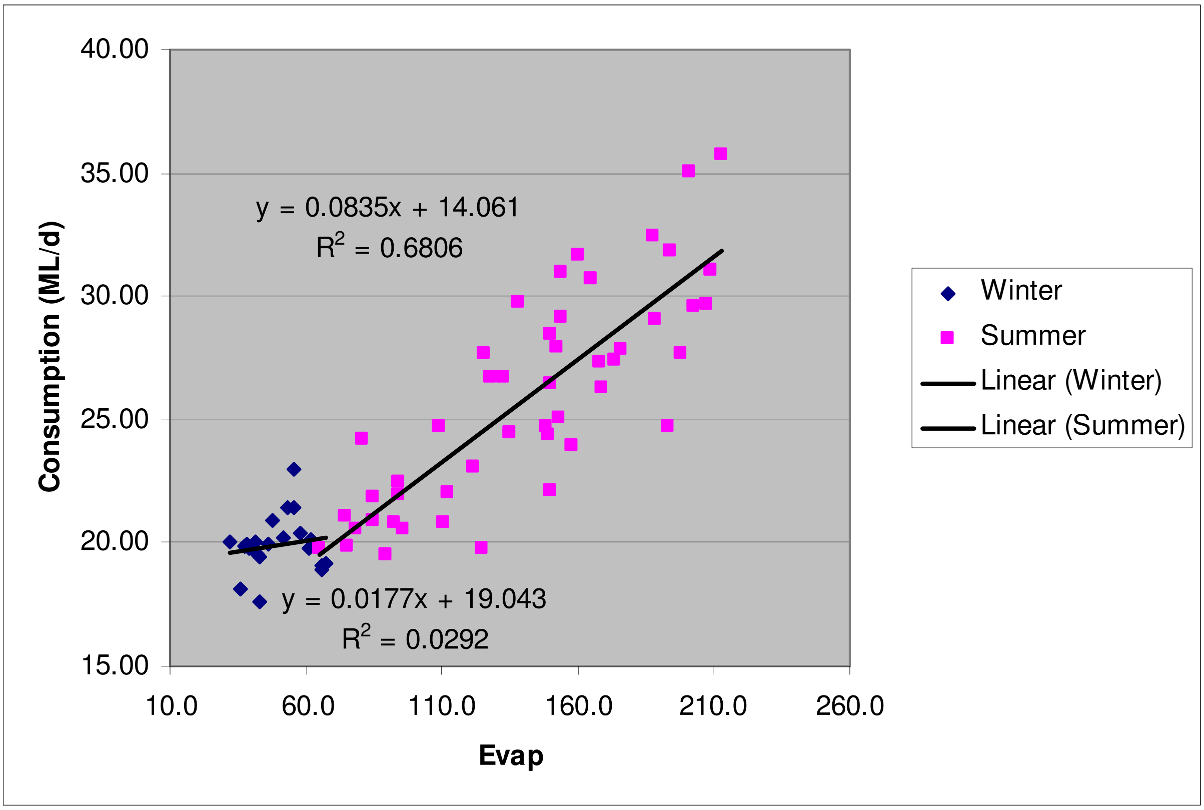

Figure 2: Correlation between Terang evaporation and "All eastern zone" consumption

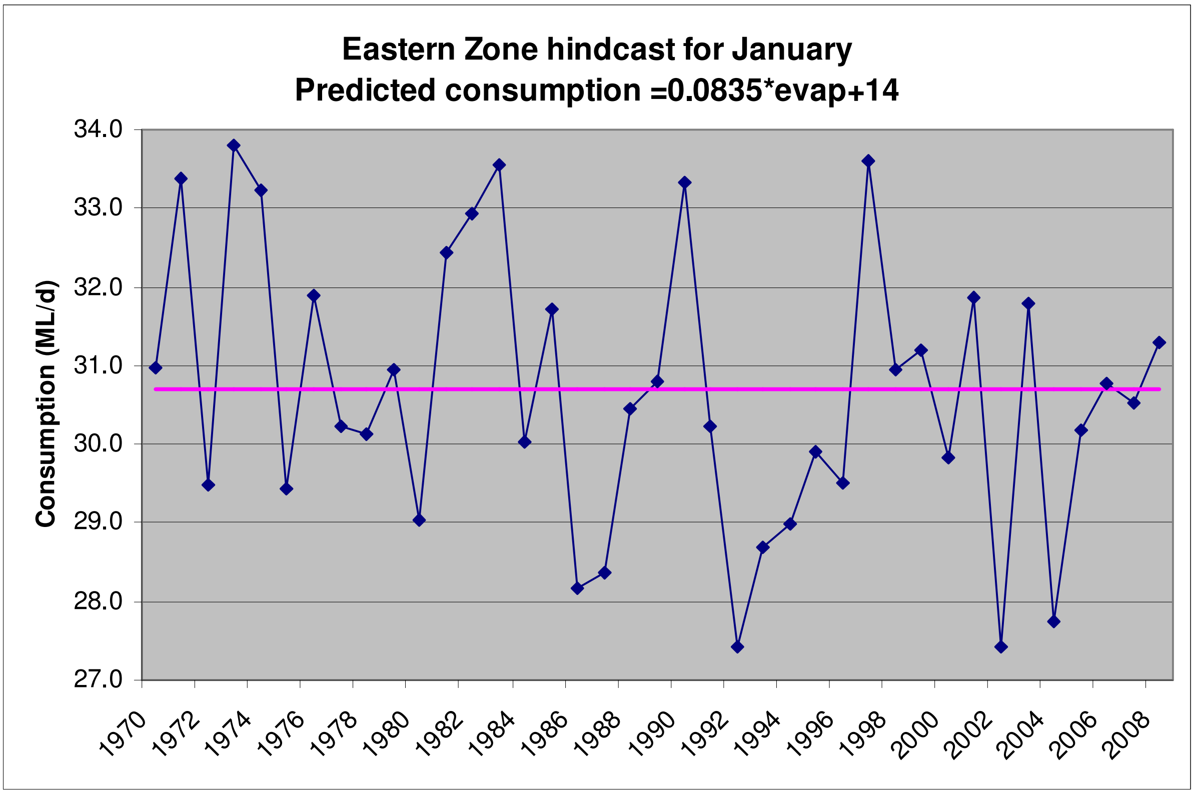

Figure 3: Hindcast of predicted "All East" consumption based on historic evaporation in Terang

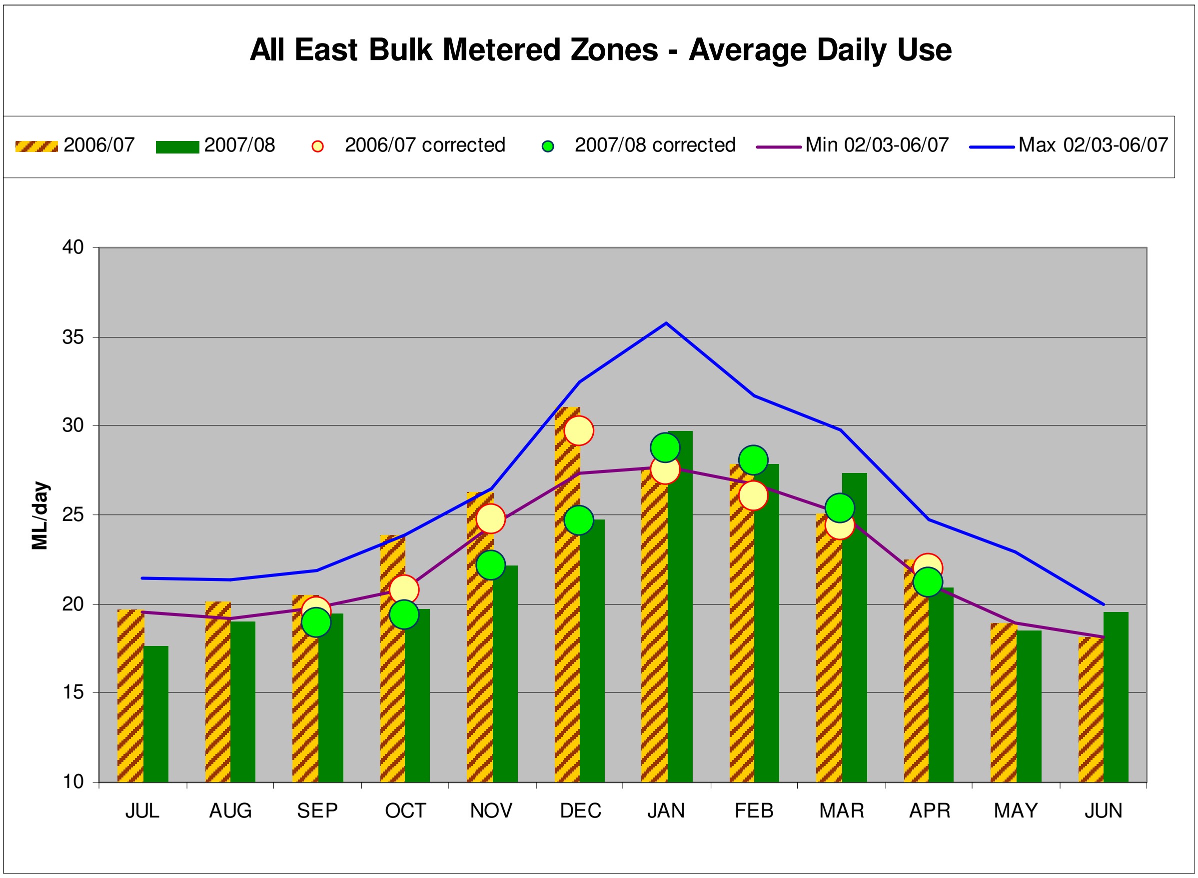

Figure 4: Observed and Climate-corrected "All East" consumption